

REMARKS

Initially, Applicants would like to thank the Examiner for the indication that claim 39 contains allowable subject matter.

In the Official Action, the Examiner argues that the publication by Martin A. Fischler et al., Random Sample Consensus: A Paradigm for Model Fitting With Applications to Image Analysis and Automated Cartography, SRI International, cited in the previously submitted Information Disclosure Statement contains missing portions. The Examiner requests that a legible copy of the reference be included in this response. Accordingly, a legible copy of the above reference is enclosed herewith.

In the Official Action, the Examiner objects to the Drawings under 37 C.F.R. § 1.83(a) because they do not show every feature specified in the claims. Specifically, the Examiner argues that the feature "reducing the size of the input image" in claims 5, 12, and 19 and an "image acquisition apparatus" which "is mounted on other apparatus" in claim 30 are not shown in the drawings. Furthermore, the Examiner argues that the shape of the markers being a polygon as recited in claim 42 is not shown in the drawings.

With regard to claims 5, 12, and 19, the same have been amended to delete the phrase "reducing the size of the input image." With regard to claims 30 and 42, the same have been canceled.

Accordingly, it is respectfully requested that the objection to the Drawings under 37 C.F.R. § 1.83(a) be withdrawn.

In the Official Action, the Examiner objects to the Abstract because it exceeds 150 words and is longer than a single page. In response, the Abstract has been deleted and a Substitute Abstract has been entered. The Substitute Abstract is 150 words and contained on

a single page. Accordingly, it is respectfully requested that the objection to the Abstract be withdrawn.

In the Official Action, the Examiner rejects claims 1-25 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Specifically, the Examiner argues that the limitation "the two-dimensional" in claim 39 has no antecedent basis. In response, "the two-dimensional" has been changed to --a two-dimensional--. Accordingly, it is respectfully requested that the rejection of claim 39 under 35 § U.S.C. 112, second paragraph, be withdrawn.

In the Official Action, the Examiner rejects claims 1-4, 8-11, 15-18, 27 and 40 under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 5,828,770 to Leis et al., (hereinafter "Leis"). Additionally, the Examiner rejects claims 5-7, 12-14, 19-21, 29, 31, 33, 34, 38, 39, and 42 under 35 U.S.C. § 103(a) as being unpatentable over Leis in view of U.S. Patent No. 5,751,843 to Maggioni et al. (hereinafter "Maggioni"). Furthermore, the Examiner rejects claim 28 under 35 U.S.C. § 103(a) as being unpatentable over Leis in view of U.S. Patent No. 5,832,139 to Batterman et al. (hereinafter "Batterman"). Still further, the Examiner rejects claim 30 under 35 U.S.C. § 103(a) as being unpatentable over Leis in view of U.S. Patent No. 6,013,308 to Saito (hereinafter "Saito"). Still further, the Examiner rejects claim 32 under 35 U.S.C. § 103(a) as being unpatentable over Leis and Maggioni and further in view of U.S. Patent No. 5,138,667 to Roch et al. (hereinafter "Roch"). Still further, the Examiner rejects claims 35 and 36 under 35 U.S.C. § 103(a) as being unpatentable over Leis and Batterman and further in view of U.S. Patent No. 6,363,169 to Ritter et al. (hereinafter "Ritter"). Still further, the Examiner rejects claim 37 under 35 U.S.C. § 103(a) as being

unpatentable over Leis and Maggioni and further in view of U.S. Patent No. 5,531,520 to Grimson et al. (hereinafter "Grimson"). Lastly, the Examiner rejects claim 41 under 35 U.S.C. § 103(a) as being unpatentable over Leis in view of U.S. Patent No. 5,440,392 to Pettersen et al. (hereinafter "Pettersen").

In response, the independent claims have been amended to clarify their distinguishing features. In summary, the claims have been amended to recite a sensing apparatus that uses one image showing at least three markers to detect the position and orientation of an object whose relationship with said at least three markers is known in advance and the position and orientation of the image acquisition apparatus. By such amendment, Applicants respectfully submit that the claims distinguish over the cited references, both individually and in combination. The primary reference cited against the claim, Leis, discloses using stereo image acquisition, which requires a plurality of images.

The amendments to the independent claims are fully supported throughout the disclosure. Specifically, the amendment --markers having color or geometric characteristics-- is fully supported in the specification at page 15, lines 4-15 and in the drawings at Figures 3-5. The amendment --as one image-- is fully supported in the drawings at Figures 1 and 2 and expressions 1, 2, 3, etc. Thus, the present amendment to the claims does not introduce new matter into the disclosure.

The present invention, as claimed, results in advantages over the apparatus and systems of the prior art. Markers are identified by their color geometric characteristics, and from the position and each marker in an image that shows at least three such markers, the position and orientation of each marker with respect to image acquisition, apparatus are calculated. Therefore, there is no need for a control section, which would have been

necessary if the markers were active markers, and using one image. In other words, by acquiring an image of an object once, it is possible to detect the position and orientation of the object with respect to the image acquisition apparatus at the time of the acquisition of the image. The technique disclosed in Leis requires a sequencer for the active markers (controls light emission timing) and two or more images (two or more times of image acquisition). Because of these differences, the present invention results in advantages over the prior art, including Leis.

Independent Claims 1, 8, and 15:

Claims 1, 8, and 15 of the present application recite an image input means substantially as follows: "image input means for inputting an image acquired by an image acquisition apparatus and showing at least three markers having color or geometric characteristics as one image, three-dimensional positional information of the markers with respect to an object to be measured being known in advance." Thus, the input means inputs one image that, within that image, are shown at least three markers having color or geometric characteristics.

In contrast, the sensor section disclosed in Leis comprises a sensor 16_{left} and another sensor 16_{right} positioned a certain distance apart from each other. In other words, Leis discloses a stereo camera, and two sensors, which produce two images. Therefore, the image input means recited in claims 1, 8, and 15 for inputting one image differs from the sensor section 16 of Leis.

In addition, the marker disclosed in Leis is an active marker (column 3 lines 57-58) and unlike the marker recited in claims 1, 8, and 15, it does not have color or geometric characteristics. In the Official Action, the Examiner states that Leis discloses

identifying the individual markers from the geometric characteristics at column 8 lines 32-38. However, Leis merely discloses, "the system has prior knowledge of the spatial relationship among the markers 14a-14d and their relationship to the geometry of the rigid body 12". Thus, Leis merely discloses that the positional relationship among the markers and their positional relationship to the body 12 are known in advance; the markers themselves do not have characteristics in their outward appearances. Therefore, Leis does not disclose the marker recited in claims 1, 8, and 15 of the present application having color or geometric characteristics. In other words, Leis does not disclose a marker characterized by color, shape or size.

Accordingly, the sensor section 16 disclosed in Leis clearly differs from the image input means recited in claims 1, 18, and 15 that inputs one image showing at least three markers having color or geometric characteristics.

The region extracting means recited in claims 1, 8, and 15 extracts regions occupied by the markers having color or geometric characteristics in the input image. In contrast, Leis discloses in column 3 lines 36-40 of 40 (cited by the Examiner) that the markers are detected; and column 7 lines 1-67, discloses that the centroids of energy of the images of markers 14a-14d are obtained. Thus, Leis does not disclose that the regions occupied by the markers in the image are extracted.

As stated above, the markers disclosed in Leis are active markers, and they are identified by the presence or absence of light emission. Therefore, the markers 14 disclosed in Leis do not have color or geometric characteristics, and they are not identified by their "color or geometric characteristics". Therefore, the marker identifying means recited in claims 1, 8, and 15 differs from that disclosed in Leis.

Step 103 in FIG 10A of Leis read “GET TABLE OF RAW ENERGY LOCATIONS FROM LEFT AND RIGHT SENSORS” (emphasis added), and it shows that to acquire an image, an image from each of the sensors 16_{left} and 16_{right} that are positioned a certain distance apart from each other is a precondition. In other words, the invention of Leis calculates position and orientation based on more than one image.

In contrast, claims 1, 8, and 15 recite position and orientation calculating means as follows: “position and orientation calculating means for calculating the three-dimensional position and orientation of the object to be measured with respect to the image acquisition apparatus, by using positions of the identified markers in the image input to the image input means, and the three-dimensional positional information of the markers with respect to the object to be measured” (emphasis added). The position and orientation calculating means obtains the position and orientation of the object with respect to the image acquisition apparatus using the positions of the markers in the one image. The invention recited in claims 1, 8, and 15 of the present application differs from Leis in the respect that the present invention does not require more than one image.

None of the other cited references discloses image input means for inputting one image that includes images of at least three markers having color or geometric characteristics, or position and orientation calculating means (for calculating the three-dimensional position and orientation of the object to be measured with respect to the image acquisition apparatus, by using positions of the identified markers in the one image input means, and the three-dimensional positional information of the markers with respect to the object to be measured).

With regard to the rejection of claims 1, 8, and 15 under 35 U.S.C. § 102(e), the above described features recited in independent claims 1, 8, and 15 are nowhere disclosed in Leis. Since it has been decided that “anticipation requires the presence in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim,”¹ independent claims 1, 8, and 15 are not anticipated by Leis. Accordingly, independent claims 1, 8, and 15 patentably distinguish over Leis and are allowable. Consequently, the Examiner is respectfully requested to withdraw the rejection of claims 1, 8, and 15 under 35 U.S.C. § 102(e).

Independent Claims 2, 9, and 16:

As in the case of claim 1, Leis does not disclose constituent features recited in claims 2, 9, and 16 corresponding to image input means for inputting one image acquired by an image acquisition apparatus and showing at least four markers having color or geometric characteristics as one image, three-dimensional positional information of the markers with respect to an object to be measured being known in advance, region extracting means for extracting an area corresponding to each marker in the range, and marker identifying the individual markers based in the color or geometric characteristics of the markers in the extracted regions.

The Examiner points out that FIG. 1 of Leis shows four markers. However, although Leis discloses that the four markers are fixed on the body 12, it does not disclose that the four markers are included in the acquired image. Therefore, the four markers of Leis and the one image showing four marks recited in claims 2, 9, and 16 of the present application cannot be considered equivalent based solely on FIG. 1 pointed out by the Examiner.

¹ Lindeman Maschinenfabrik GMBH v. American Hoist and Derrick Company, 730 F.2d 1452, 1458; 221 U.S.P.Q. 481, 485 (Fed. Cir., 1984).

Further, column 6 lines 26-29 of Leis, which is also pointed out by the Examiner, discloses that when there is only one marker 14a in the circular boundary, B, the DSP 22 concludes that it is identifying the marker 14a and the DSP is unable to find the marker 14b. In other words, it does not actively select a marker. In addition, Leis does not disclose "evaluating application of the parameters calculated by the parameter means, to markers not selected" as is recited in claims 2, 9, and 16

The other cited references also do not disclose the image input means, parameter calculating means, or parameter selecting means recited in claims 2, 9, and 16 of the present application.

With regard to the rejection of claims 1, 2, 3, 10, 16, and 17 under 35 U.S.C. § 102(b), the above described features recited in independent claims 2, 9, and 16 are nowhere disclosed in Leis. Since it has been decided that "anticipation requires the presence in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim,"² independent claims 2, 9, and 16 are not anticipated by Leis. Accordingly, independent claims 2, 9, and 16 patentably distinguish over Leis and are allowable. Claims 3, 10, and 17 being dependent upon claims 2, 9, and 16 are thus allowable therewith. Consequently, the Examiner is respectfully requested to withdraw the rejection of claims 1, 2, 3, 10, 16, and 17 under 35 U.S.C. § 102(e).

Independent Claims 4, 11, and 18:

As in the case of claim 1 of the present application, Leis does not disclose constituent features recited in claims 4, 11, and 18 corresponding to the image input means,

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Id.

region extracting means, and marker identifying means recited in claims 4, 11, and 18 of the present application.

Further, as stated in the discussion on claim 1, the invention of Leis is a system of the so-called compound eye, using two sensors, and therefore, more than one image is acquired and the size of an object and distance are calculated from these images. Further, column 3 lines 64-67 and column 4 lines 1-3 pointed out by the Examiner merely discloses the effect that the two sensors are fixed at positions a certain distance apart from each other and have fields or view wide enough to allow measurement of the size of an object to be measured. However, the specifics of this process are not disclosed in Leis.

In contrast, the invention recited in claims 4, 11, and 18 of the present application uses distance estimating means for estimating a distance from the image acquisition apparatus to each marker based on the size of the extracted region in the (inputted one) image.” In other words, based on the size of the region occupied by a marker in the one image, the distance between the marker and the image acquisition apparatus is estimated. Therefore, the distance, the distance estimating means recites in claims 4, 11, and 18 entirely differs from that disclosed in Leis.

With regard to the rejection of claims 4, 11, and 18 under 35 U.S.C. § 102(b), the above described features recited in independent claims 4, 11, and 18 are nowhere disclosed in Leis. Since it has been decided that “anticipation requires the presence in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim,”³ independent claims 4, 11, and 18 are not anticipated by Leis. Accordingly, independent claims 4, 11, and 18 patentably distinguish over Leis and are allowable.

³ Id.

Consequently, the Examiner is respectfully requested to withdraw the rejection of claims 4, 11, and 18 under 35 U.S.C. § 102(b).

With regard to the rejection of claims 6, 13, and 20 under 35 U.S.C. § 103(a), since independent claims 4, 11, and 18 patentably distinguish over the prior art and are allowable, claims 6, 13, and 20 are allowable therewith at least because they depend from an allowable base claim. Consequently, the Examiner is respectfully requested to withdraw the rejection of claims 6, 13, and 20 under 35 U.S.C. § 103(a).

Independent Claims 5, 12, and 19:

Column 9 lines 30-39 of Maggioni discloses that once the marking structure has been found, it is unnecessary to search the entire image plane and so it is sufficient to search part of the image plane. In other words, the search area is restricted in Maggioni instead of changing the image size.

In contrast, claims 5, 12, and 19 of the present application recite “region extracting means for reducing the size of the input image and extracting a region corresponding to each marker in the reduced image.” That is, after reducing the image size, the region of each marker is extracted using the reduced image.

Therefore, the technique disclosed in column 9 lines 30-39 of Maggioni differs from the region extracting means recited in claims 5, 12, and 19 of the present application.

Independent claims 5, 12, and 19 are not rendered obvious by the cited references because neither the Leis nor the Maggioni patents, whether taken alone or in combination, teach or suggest a three-dimensional positional and orientation sensing apparatus having the features discussed above. Accordingly, claims 5, 12, and 19 patentably distinguish over the prior art and are allowable. Claims 7, 14, and 21, being dependent upon

claims 5, 12, and 19, are thus allowable therewith. Consequently, the Examiner is respectfully requested to withdraw the rejection of claims 5, 7, 12, 14, 19, and 21 under 35 U.S.C. § 103(a).

Independent Claim 27:

Similarly to that discussed above with regard to Leis and claim 1 of the present application, Leis does not disclose the feature “by measuring image positions of at least three markers mounted on the object or near the object, based on an image showing the markers, acquired by the image acquisition apparatus, wherein the markers have color or geometric characteristics and three-dimensional positions of the markers are known in advance.” The other cited references also do not disclose such means that uses one image showing at least markers.

With regard to the rejection of claims 27 and 40 under 35 U.S.C. § 102(e), the above described features recited in independent claim 27 are nowhere disclosed in Leis. Since it has been decided that “anticipation requires the presence in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim,”⁴ independent claim 27 is not anticipated by Leis. Accordingly, independent claim 27 patentably distinguishes over Leis and is allowable. Claim 40 being dependent upon claim 27 is thus allowable therewith. Consequently, the Examiner is respectfully requested to withdraw the rejection of claims 27 and 40 under 35 U.S.C. § 102(b).

With regard to the rejection of claims 28-39, 41, and 42 under 35 U.S.C. § 103(a), since independent claim 27 patentably distinguishes over the prior art and is allowable, claims 28, 29, 31-39, and 41 are allowable therewith at least because they depend

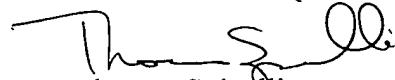
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Id.

from an allowable base claim, claims 30 and 42 being canceled. Consequently, the Examiner is respectfully requested to withdraw the rejection of claims 28-39, 41, and 42 under 35 U.S.C. § 103(a).

Lastly, new claims 43-47 have been added. Applicants respectfully submit that the same patentably distinguish over the cited references for reasons similar to that outlined above with regard to claims 1, 2, 4, 5, and 27. New claims 43-47 are fully supported in the original disclosure. Thus, no new matter has been entered into the disclosure by way of the addition of new claims 43-47.

Respectfully submitted,



Thomas Spinelli
Registration No.: 39,533

Scully, Scott, Murphy & Presser
400 Garden City Plaza
Garden City, New York 11530
(516) 742-4343

TS:cm

Encl. (Fischler et al., Random Sample Consensus: A Paradigm for Model Fitting With Applications to Image Analysis and Automated Cartography, SRI International)